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Short Synopsis

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TITLE: DESIGN AND EXPERIMENTAL ANALYSIS OF PROTOTYPE SOLAR STILLS USING NANO-CONDENSING COVERS

DEPARTMENT OF CHEMISTRY

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Abstract

Fresh water is the basic necessity for the survival of human life. It is the foremost requirement for all our domestic, industrial and agricultural growth. Supplying potable water is still one of the biggest challenging jobs in different parts of the world especially in remote areas. Solar stills can be the best solution for providing potable water in these areas where availability of solar energy is plenty but water quality is not up to the mark. Solar stills are cheap and have low maintenance cost but the only problem attributed to this meaningful device is its low productivity.

In the proposed problem, extensive research work will be carried out to analyze the water and glass temperatures of solar still and thus to obtain the distillate using the experimental observations for outdoor distillation. Nano-coated condensing covers of different materials like Indium tin oxide (ITO), Fluorine doped tin oxide (FTO) and Graphene will be used. As they have high transmission as compared to simple glass cover, so their nano coating will give considerable distillate. A detailed comparison of the performance of solar stills having nano-coated condensing covers with conventional single slope solar still will be done.

Key words: - Potable Water, Solar Still, Distillation, Condensing Cover, Nano-condensing Covers

Contents

S.No.	Description	Pages
1.	Introduction	1-2
2.	Literature Survey	2-4
3.	Description of Broad Area	4-5
4.	Objective of the study	5
5.	Methodology to be adopted	5-6
6.	Expected outcome of the results	6
7.	Proposed time frame	7
8.	Reference	8-11

Introduction

Water is the most vital resource for life. In our planet earth, approximately 97.2% water lies in oceans as salt water, while 2.15% in frozen ice form and the remaining 0.65% remains as fresh water. The demand for fresh water has increased day by day and will increase with the rapid growth of population, agriculture and industry. As a result the fresh water reserve depletes day by day. The requirement of clean water per person is about 2.7 m^3 per day, thus the global requirement is about 16.5 billion m^3 per day only for drinking purpose.

In India over 3 trillion m^3 of water is received from rainfall, which is among the highest in the world. Fourteen major river systems share 83% of the drainage. Basin account for 85 % of the surface flow and serve 80% of the total population of the country. There are also 44 medium and 55 minor rivers which mostly originate in the coastal mountains and 80% of their discharge occurs during the monsoon months. With respect to ground water reserves in India, the estimated availability of ground water is to be over 210 billion m^3. In spite of fairly high amount of available fresh water, India has a very low per capita availability of drinking water, about 2.43 thousand m^3 per year. Many organizations like United Nations (UN), World Health Organization (WHO) and the World Bank are actively involved in encouraging the projects related to supply of fresh healthy water. There were a large number of swamps and wetlands in India, which are essential for a balanced ecosystem, but these areas are currently disappearing for human transformation. The water crisis is no longer a futuristic prediction for India. It is an increasing prevalent feature, resulting from an overall disruption of the hydrological cycle. Thus there is a vital need for a national water policy to ensure sustainable availability and use of water for diverse objectives. For millions of people a shortage of clean drinking water is reality they must face every day. Sometimes they simply do not have enough; in other cases the available water is contaminated. In developing countries, poor water quality is the leading cause of health problems. 80% of all illness in developing countries is caused by polluted water. It is estimated that 2 million people die every year from these illness. According to a recent WHO report 1.8 million people die from diarrheal diseases each year. Later on, it was estimated that 94 percent of these diarrheal cases can be prevented through by providing healthy drinking water. Excess of salinity causes many health problems like taste, stomach ache and laxative effects. With the

advent of number of desalination methods like reverse osmosis, electrodialysis, vapor compression, multi-stage flash distillation which are having their own pros. and cons., among these, the solar stills is different and can be used in remote settlements where power is scarce and demand is less than 200 m^3/day. On the other hand setting of fresh water pipelines for such areas is uneconomical and expensive. Since other desalination methods are expensive for the low capacity fresh water demand, thereby, under these conditions, solar stills are considered most reliable and ensure regular supply of fresh water.

Literature Survey

Solar distillation is a solar technology which requires latent heat of evaporation of 2260 kJ /kg to evaporate water. The entire process take place in an enclosure, made up of fiber re-inforced plastic (FRP) to prevent heat loss .The incident solar radiation is transmitted through the condensing cover made of glass and is absorbed by black surface. Subsequently water gets heated up and gives off water vapor. The vapor condenses on the sloped glass cover, which is at a lower temperature because it is in contact with the ambient air.

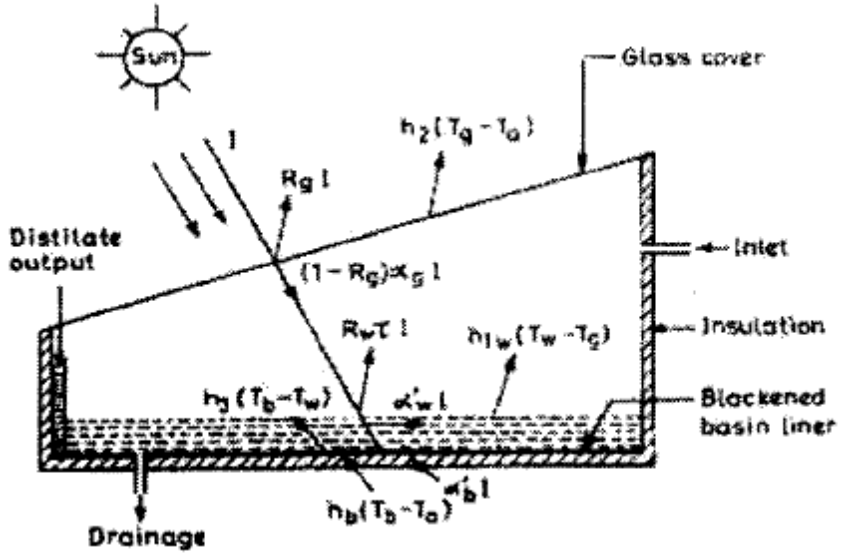

Fig 1. Schematic diagram of a conventional single slope solar still

Solar distillation is a process where solar energy is utilized in converting saline/brackish water to fresh water. It is broadly classified into two types, namely active & passive distillation systems. In active solar distillation systems the external energy source is required apart from solar energy whereas in passive mode no such external energy is required. Fig.1 shows a conventional single slope solar still in which the various components of energy balance and thermal energy loss is shown encompassing the entire process. It has an air tight basin, usually constructed out of concrete/cement, galvanized iron sheet (GI) or fiber re-inforced plastic (FRP) with a top cover of transparent material like glass, plastic etc. The solar radiation after transmitting through the glass surface, finally reaches to basin water which is made blackened to efficiently absorb the incident solar radiation. There are three major physical processes that take place on the glass surface, namely reflection, absorption and transmittance of solar radiation. The solar radiation after reaching the glass surface undergoes reflection and absorption and then transmitted inside the enclosure of the distillate unit. In the basin water, the transmitted radiation is further partially reflected and absorbed by the water surface. A major part of absorbed energy is convected to water mass and rest is lost to atmosphere through insulation. The attenuation of solar flux in water mass depends on its absorptivity and depth. Consequently the water gets heated, leading to an increased difference of water & glass cover temperatures. There are three modes of heat transfer namely radiation, convection and evaporation from the water surface to the glass cover. The evaporated water gets condensed on the inner surface of the glass cover after releasing the latent heat. The condensed water trickles into the channel provided at the lower end of glass cover, under gravity. The collected water in the channel is taken out of the system for further use.

In fourth century B.C., Aristotle described a method to evaporate impure water and then condense it for potable use. However, historically the earliest documented work on solar distillation was by Arab alchemist in the 16^{th} century [28]. Della Porta [9] used wide earthen pots, which were exposed to the sunlight to evaporate water and collect the condensate into vases placed underneath [30].

Talbert et al. [37] gave excellent historical reviews of solar distillation. Delyannis & Delyannis [12] reviewed the major solar distillation plants around the world. This review also included the work of Delyannis [10], Delyannis & Piperoglou [14] & Delyannis & Delyannis [11]. Malik et al. [27] reviewed the work on passive solar distillation system till 1982 and this

was updated up to 2003 by Tiwari et al. [42] which also included active and hybrid solar distillation. Kaushal and Varun [22] reviewed different types of solar still and stressed for the requirement of a selected solar still based upon the local operating conditions.

Delyannis [13] reviewed the status of solar assisted desalination. Gomkale [21] studied in detail the solar distillation system as per Indian scenario. Fath [18] reviewed various designs of solar stills and studied the sustainability of solar stills for providing potable water. Different types of solar stills available in the literature are Conventional Solar Stills, Single-Slope Solar Still with passive condenser, Double Condensing Chamber Solar Still [43], Vertical Solar Still [7; 23], Conical Solar Still [44], Inverted Absorber Solar Still [36], Multi-Wick Solar Still [20; 35; 43] and Multiple Effect Solar Still [4; 19; 1; 17; 39].

Description of Broad Area

As per documented literature survey, research in the area of solar distillation is going on in the following academic organizations to enhance the efficiency of solar still and thus distillate, numerous work have been done so far in different places namely IIT Delhi, CAZRI, Jodhpur, and SPRERI, Anand, Solar Energy Laboratory, Coimbatore, Tamil Nadu, NIT (Hamirpur) (India); UNAM Ciudad Universitaria, Coyoacaan (Mexico); RYUKYUS, NAGOYA and CHUO Universities (Japan); BEN-GURION University of the Negev (Israel); TECHNISCHE University Bergakademie Freiberg (Germany); ALEXANDRIA University (Egypt); Jordan University of Science and Technology, Irbid (Jordan); university of Ouargla (Algeria); XiAn Jiao Tong University (China);University of Foggia (Italy); NCSR "DEMOKRITOS" Laboratory for Solar and other Energy Systems (Greece).University of Strathclyde, Glasgow,(UK). For better performance of a conventional solar still following modifications were suggested by various researchers: reducing bottom loss coefficient [8; 40] reducing water depth in basin/ Multi-Wick Solar Still [40; 48; 25], Effect of water depth [45],using reflector [47; 38] using internal [2] & external condensers [16], using black wall with cotton cloth [47], use of dye [33; 34; 32], use of charcoal [29], use of sponge cubes [6], using Multi-wick solar still [35], condensing cover cooling [3; 41; 5), inclined solar still [27], increasing evaporative area [25],use of solar fraction [46].

To study the heat and mass transfer relations for a solar still, various models have been studied, namely: The Chilton-Colburn Analogy [31], Model for computation of solar fraction in a single-slope solar still [26], Model for computation of *C* and *n* [24], Dunkle's relation [15].

Objective of the Study

1. The main objective of the proposed work is to design a prototype solar still for domestic application.
2. To explore and use new materials or condensing cover / nano- condensing covers for better efficiency of solar still.
3. To study and analyze the water and glass temperatures for the newly constructed distillation units.
4. To compare the performance of solar stills having nano-coated condensing covers with conventional single slope solar still.

Methodology to be adopted

The process of solar distillation is used to distill brackish/saline water by using solar energy. The system involved in solar distillation operates under two modes: passive and active.

Solar distillation is mainly used as a source of freshwater in addition to its use in industries and agriculture. The passive solar stills of conventional type or new designs are specifically meant to get distilled water for domestic purposes, while the active solar distillation units are beneficial and cost effective only when they are installed from commercial point of view for large-scale applications in industries. The selection of a solar distillation unit depends on its performance. This is because of best maintenance and suitable conditions chosen for short-term, while in long-term there is deterioration in maintenance and occurrence of unfavorable conditions like clouds, rain, haze and fog.

1. Literature survey on the solar still considering various designs and other modification like change in angle, basin materials etc.

2. Prototype solar stills of size one square feet will be designed.
3. New materials / condensing covers will be used for developing a domestic model of solar still.
4. Different new condensing covers like Fluorine doped tin oxide (FTO) glass, Indium Tin Oxide (ITO) glass and Graphene etc. for achieving better performance of solar still will be used for studies.
5. Different parameters will be studied like refractive index, transmittance, gravity, tensile strength, resistance etc. will be studied.
6. Comparison and performance of solar stills will be made after analyzing all experimental results for conclusions and application having nano-coated condensing covers with conventional single slope solar still.

Expected outcome of the results

In the present scenario purification of water without disturbing the ecosystem is the need of the hour. In this context, many conventional and non conventional techniques have been developed for purification of saline/brackish water. The solar distillation techniques are both economical and eco-friendly particularly in rural areas. since the nano coated covers of FTO, ITO and Graphene have high percentage of transmittance thus increasing the yield by evaporating more water and thus higher output.

1. Nano coated glass covers not only increases the yield but also have several significances over the simple glass condensing covers. It protects glass from corrosion, Easy application through spraying, polishing, immersion, smearing etc, Stable at varying temperatures ,Low cleaning and maintenance requirement, Resistance against; dirt, algae, scales etc.

2. The investigated results of proposed research outcome at every stage will be published in national and international journals in the field of solar distillation.

3. The proposed research outcome will also contribute towards the opening for new research work.

Proposed time frame

Work / Time	First Year		Second Year		Third Year		Fourth Year	
	Six Months	Six Months	Six Months	Six Months	Six Months	Six Months	Six Months	Six Months
Course work & Literature Survey	←	→						
Synthesis and optimization of parameters			←	→				
Characterization				←	→			
Analysis & Paper Writing					←	→		
Thesis Writing & Submission							←	→

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